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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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# DRIVING ROCK SLOPES AT THE NEW PEERLESS MINE

BY

ROBERT HOWARD

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# DRIVING ROCK SLOPES AT THE NEW PEERLESS MINE[1]

By Robert Howard[2]

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## INTRODUCTION

With the rapid depletion of the Peerless Coal Co.'s mine in Spring Canyon, it was necessary, if the company was to remain in the coal-producing business, to look to the development of a new property or to acquire a mine already developed. After careful investigation of several operating properties it was decided by the officials of the company to take over the lease on an undeveloped acreage held by a private party in Price Canyon, about 3 miles north of Castle Gate, Utah.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6277."

[2] - Superintendent, Peerless Coal Co., and Consulting Engineer, U. S. Bureau of Mines.

In Price Canyon, in which the Price River runs, is also located the main line of the Denver & Rio Grande Western Railroad. It is less than one quarter mile wide, and its walls rise nearly vertically 1,000 to 1,200 feet above the river bed.

The acreage acquired consists of 1,800 acres of coal land leased from the Federal Government and a 160-acre homestead of surface rights. A plan of the property, showing a portion of Price Canyon and the location of the river, main line of the railroad, and location of drill holes is shown in Figure 1.

## HISTORY

The officials of the company in charge of operations are as follows:

| | |
|---|---|
| President and general manager | L. H. Thompson |
| Vice president | E. P. Thompson |
| Secretary | W. W. Murdock |
| Treasurer | C. R. Thompson |
| Superintendent | Robert Howard |

From 1917 to date these officials have supervised the mining of approximately 2,000,000 tons of coal for the commercial market from the present Peerless mine, situated in the Spring Canyon district of Carbon County, Utah. The tract mined contains only 97 acres of profitable coal-bearing land and has proved to be one of the most economical and safest operations in the State.

### Geological Measures

The coal-bearing rocks of the district are contained within the upper Mesaverd group of the Blackhawk formation, Cretaceous period, and are composed of sandstones, shales, and numerous coal beds ranging from 6 inches to over 20 feet in thickness. The outstanding member of this group is the Aberdeen sandstone, which ranges from 100 to 140 feet in thickness and which may be observed on the outcrop of the Book Cliffs coal field for many miles.

### Method of Prospecting

The property was prospected by three diamond drill holes, one placed near the present location of the slopes, one near Castle Rock approximately 2,800 feet southeast, and one in Crandell Canyon approximately 5,000 feet slightly northwest of the slopes. During the driving of the slopes the findings of the diamond-drill holes have been closely verified. A typical section of the measures above the coal beds and the coal beds to be mined is shown in Figure 2.

### Coal Beds

The two principal coal beds to be mined are the Castle Gate "A", which is being mined at the present time at several operations in this locality, and the "D", which is being mined in the adjacent mine. The coal beds dip 7° 57' in the direction of N8° 30'E.

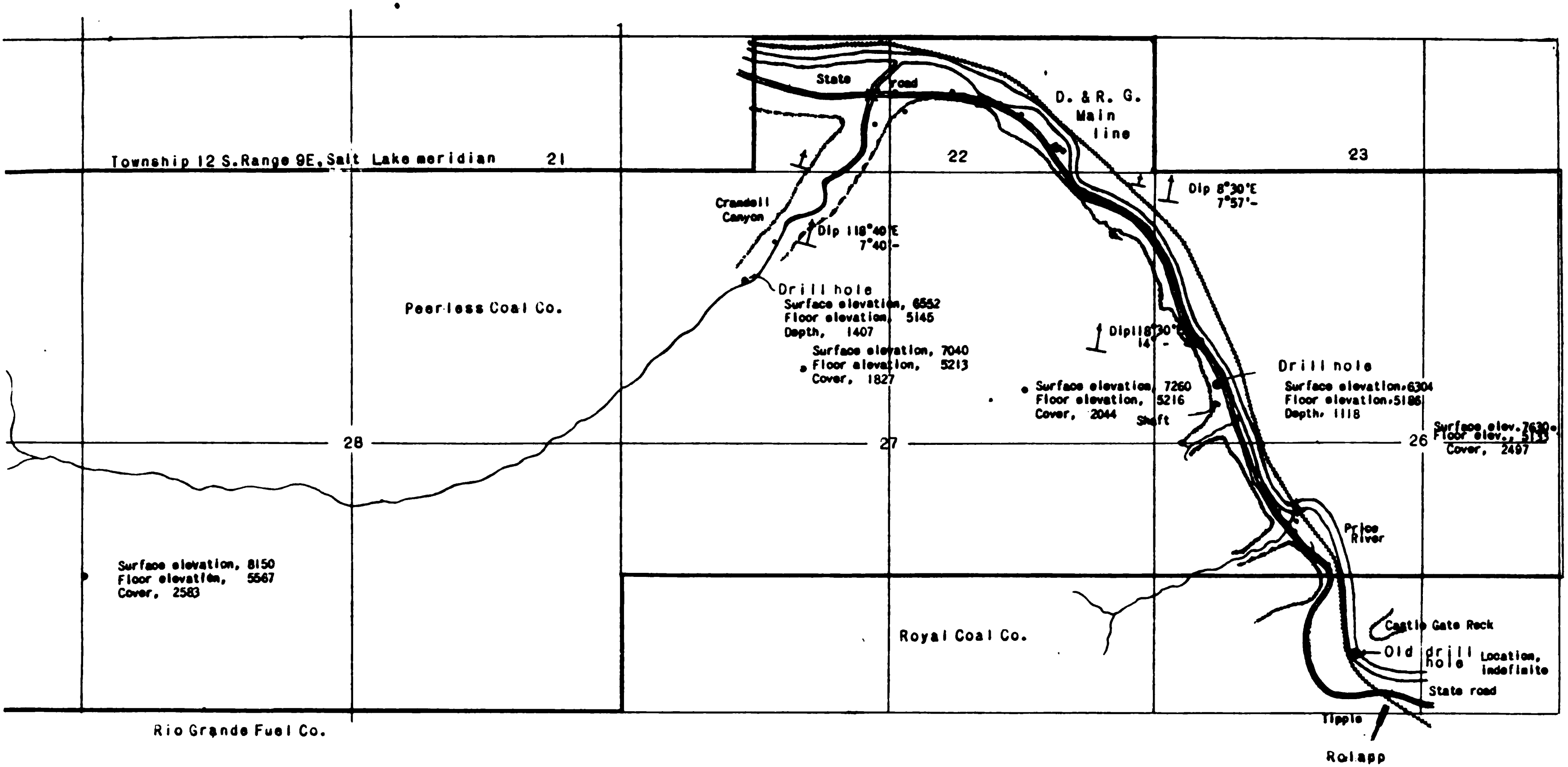
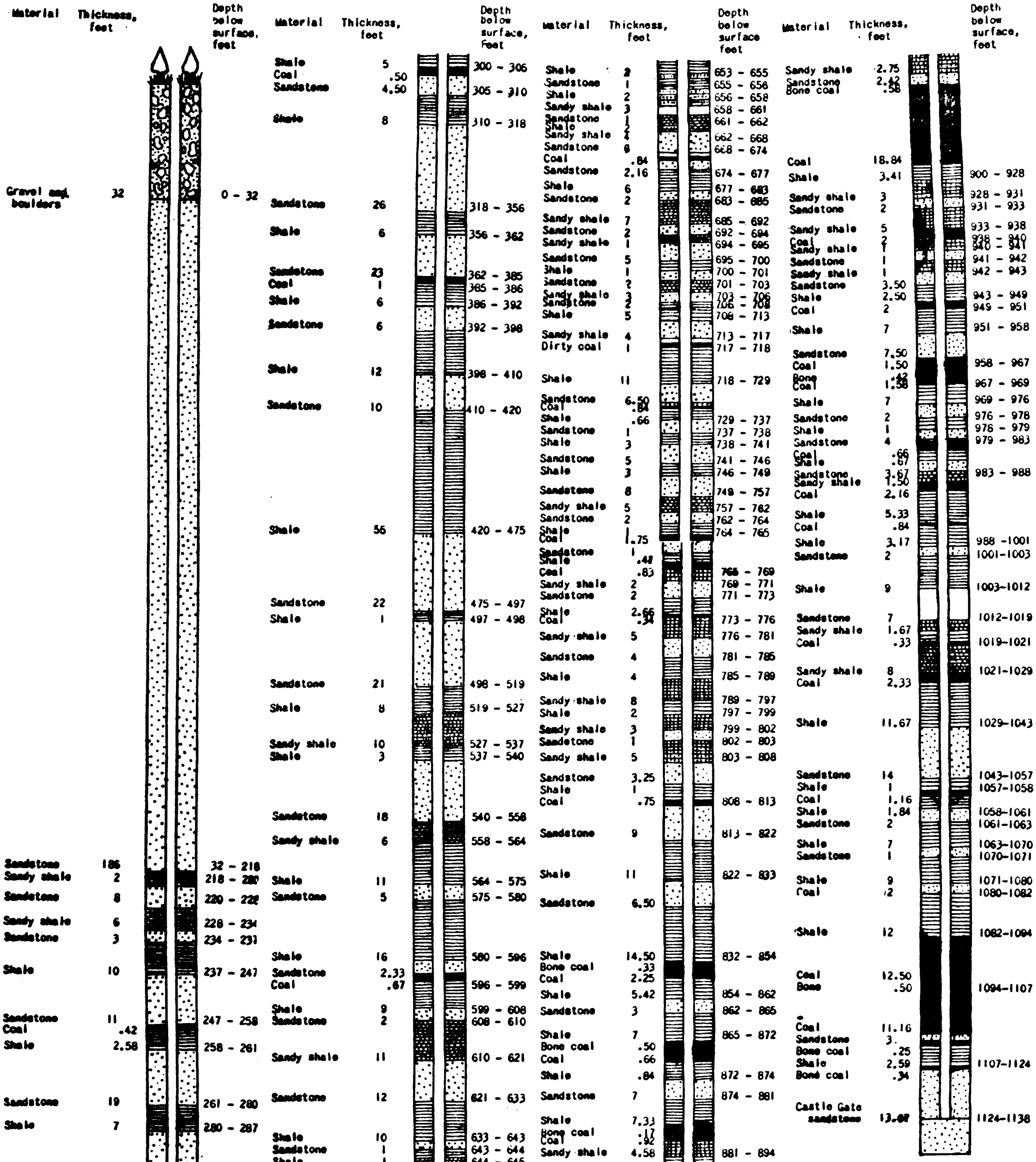


Figure 1. - Reconnaissance map for Peerless Coal Co. in Price Canyon, showing location of drill holes



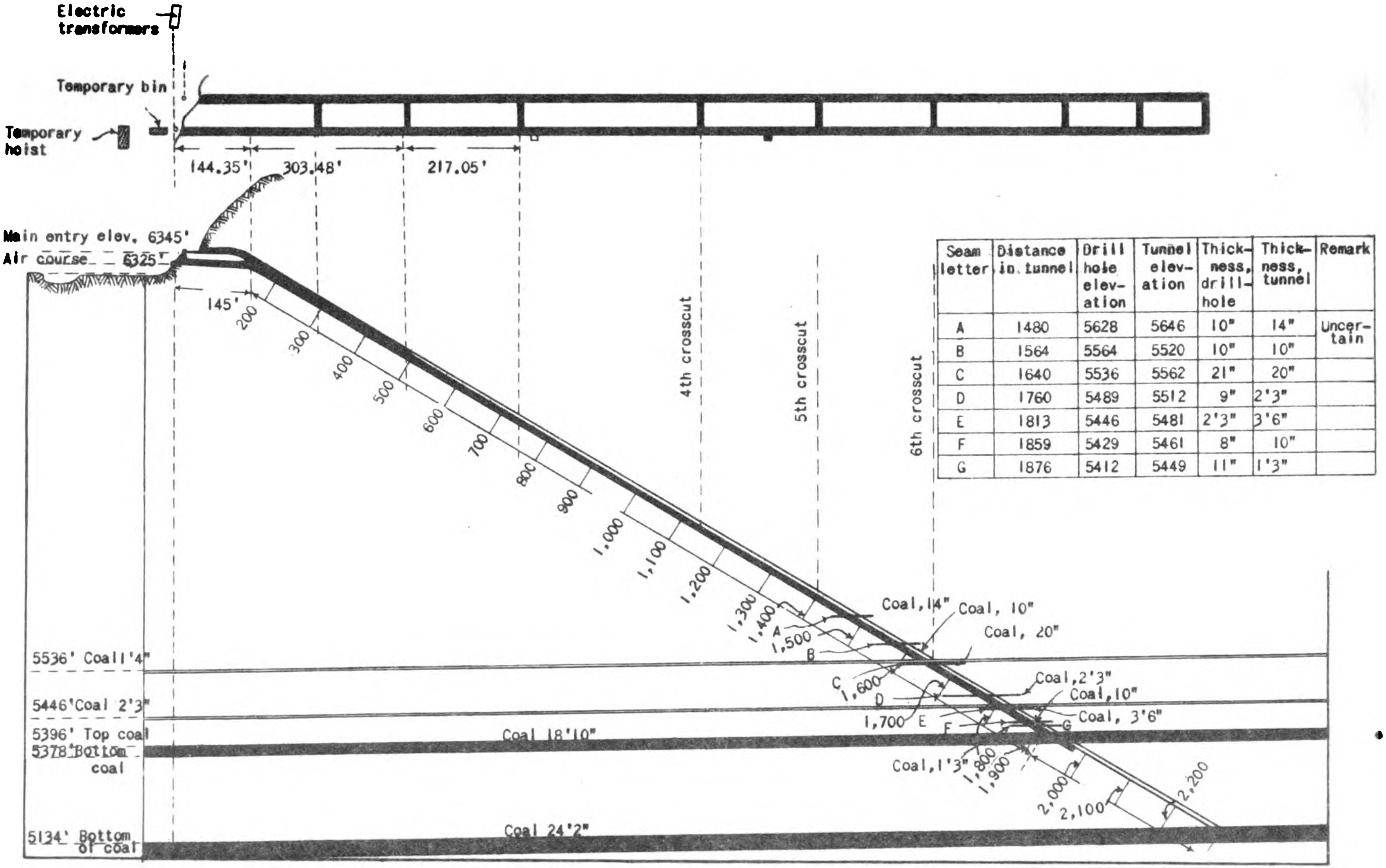
| Material | Thickness, feet | Depth below surface, feet |
|---|---|---|
| Gravel and boulders | 32 | 0 - 32 |
| Sandstone | 186 | 32 - 218 |
| Sandy shale | 2 | 218 - 220 |
| Sandstone | 8 | 220 - 228 |
| Sandy shale | 6 | 228 - 234 |
| Sandstone | 3 | 234 - 237 |
| Shale | 10 | 237 - 247 |
| Sandstone | 11 | 247 - 258 |
| Coal | .42 | |
| Shale | 2.58 | 258 - 261 |
| Sandstone | 19 | 261 - 280 |
| Shale | 7 | 280 - 287 |
| Sandstone | 13 | 287 - 300 |

| Material | Thickness, feet | Depth below surface, feet |
|---|---|---|
| Shale | 5 | 300 - 306 |
| Coal | .50 | |
| Sandstone | 4.50 | 305 - 310 |
| Shale | 8 | 310 - 318 |
| Sandstone | 26 | 318 - 356 |
| Shale | 6 | 356 - 362 |
| Sandstone | 23 | 362 - 385 |
| Coal | 1 | 385 - 386 |
| Shale | 6 | 386 - 392 |
| Sandstone | 6 | 392 - 398 |
| Shale | 12 | 398 - 410 |
| Sandstone | 10 | 410 - 420 |
| Shale | 56 | 420 - 475 |
| Sandstone | 22 | 475 - 497 |
| Shale | 1 | 497 - 498 |
| Sandstone | 21 | 498 - 519 |
| Shale | 8 | 519 - 527 |
| Sandy shale | 10 | 527 - 537 |
| Shale | 3 | 537 - 540 |
| Sandstone | 18 | 540 - 558 |
| Sandy shale | 6 | 558 - 564 |
| Shale | 11 | 564 - 575 |
| Sandstone | 5 | 575 - 580 |
| Shale | 16 | 580 - 596 |
| Sandstone | 2.33 | |
| Coal | .67 | 596 - 599 |
| Shale | 9 | 599 - 608 |
| Sandstone | 2 | 608 - 610 |
| Sandy shale | 11 | 610 - 621 |
| Sandstone | 12 | 621 - 633 |
| Shale | 10 | 633 - 643 |
| Sandstone | 1 | 643 - 644 |
| Shale | 1 | 644 - 645 |
| Sandy shale | 8 | 645 - 653 |

| Material | Thickness, feet | Depth below surface, feet |
|---|---|---|
| Shale | 2 | 653 - 655 |
| Sandstone | 1 | 655 - 656 |
| Shale | 2 | 656 - 658 |
| Sandy shale | 3 | 658 - 661 |
| Sandstone | 1 | 661 - 662 |
| Shale | 2 | |
| Sandy shale | 4 | 662 - 668 |
| Sandstone | 6 | 668 - 674 |
| Coal | .84 | |
| Sandstone | 2.16 | 674 - 677 |
| Shale | 6 | 677 - 683 |
| Sandstone | 2 | 683 - 685 |
| Sandy shale | 7 | 685 - 692 |
| Sandstone | 2 | 692 - 694 |
| Sandy shale | 1 | 694 - 695 |
| Sandstone | 5 | 695 - 700 |
| Shale | 1 | 700 - 701 |
| Sandstone | 2 | 701 - 703 |
| Sandy shale | 3 | 703 - 706 |
| Sandstone | 2 | 706 - 708 |
| Shale | 5 | 708 - 713 |
| Sandy shale | 4 | 713 - 717 |
| Dirty coal | 1 | 717 - 718 |
| Shale | 11 | 718 - 729 |
| Sandstone | 6.50 | |
| Coal | .84 | |
| Shale | .66 | 729 - 737 |
| Sandstone | 1 | 737 - 738 |
| Shale | 3 | 738 - 741 |
| Sandstone | 5 | 741 - 746 |
| Shale | 3 | 746 - 749 |
| Sandstone | 8 | 749 - 757 |
| Sandy shale | 5 | 757 - 762 |
| Sandstone | 2 | 762 - 764 |
| Shale<br>Coal | 1.75 | 764 - 765 |
| Sandstone | 1 | |
| Shale | .47 | |
| Coal | .83 | 765 - 769 |
| Sandy shale | 2 | 769 - 771 |
| Sandstone | 2 | 771 - 773 |
| Shale | 2.66 | |
| Coal | .34 | 773 - 776 |
| Sandy shale | 5 | 776 - 781 |
| Sandstone | 4 | 781 - 785 |
| Shale | 4 | 785 - 789 |
| Sandy shale | 8 | 789 - 797 |
| Shale | 2 | 797 - 799 |
| Sandy shale | 3 | 799 - 802 |
| Sandstone | 1 | 802 - 803 |
| Sandy shale | 5 | 803 - 808 |
| Sandstone | 3.25 | |
| Shale | 1 | |
| Coal | .75 | 808 - 813 |
| Sandstone | 9 | 813 - 822 |
| Shale | 11 | 822 - 833 |
| Sandstone | 6.50 | |
| Shale | 14.50 | 832 - 854 |
| Bone coal | .33 | |
| Coal | 2.25 | |
| Shale | 5.42 | 854 - 862 |
| Sandstone | 3 | 862 - 865 |
| Shale | 7 | 865 - 872 |
| Bone coal | .50 | |
| Coal | .66 | |
| Shale | .84 | 872 - 874 |
| Sandstone | 7 | 874 - 881 |
| Shale | 7.33 | |
| Bone coal | .17 | |
| Coal | .92 | |
| Sandy shale | 4.58 | 881 - 894 |
| Shale | 6 | 894 - 900 |

| Material | Thickness, feet | Depth below surface, feet |
|---|---|---|
| Sandy shale | 2.75 | |
| Sandstone | 2.42 | |
| Bone coal | .58 | |
| Coal | 18.84 | |
| Shale | 3.41 | 900 - 928 |
| Sandy shale | 3 | 928 - 931 |
| Sandstone | 2 | 931 - 933 |
| Sandy shale | 5 | 933 - 938 |
| Coal | 2 | 938 - 940 |
| Sandy shale | 1 | 940 - 941 |
| Sandstone | 1 | 941 - 942 |
| Sandy shale | 1 | 942 - 943 |
| Sandstone | 3.50 | |
| Shale | 2.50 | 943 - 949 |
| Coal | 2 | 949 - 951 |
| Shale | 7 | 951 - 958 |
| Sandstone | 7.50 | |
| Coal | 1.50 | 958 - 967 |
| Bone | .42 | 967 - 969 |
| Coal | 1.58 | |
| Shale | 7 | 969 - 976 |
| Sandstone | 2 | 976 - 978 |
| Shale | 1 | 976 - 979 |
| Sandstone | 4 | 979 - 983 |
| Coal | .66 | |
| Shale | .67 | |
| Sandstone | 3.67 | 983 - 988 |
| Sandy shale | 1.50 | |
| Coal | 2.16 | |
| Shale | 5.33 | |
| Coal | .84 | |
| Shale | 3.17 | 988 -1001 |
| Sandstone | 2 | 1001-1003 |
| Shale | 9 | 1003-1012 |
| Sandstone | 7 | 1012-1019 |
| Sandy shale | 1.67 | |
| Coal | .33 | 1019-1021 |
| Sandy shale | 8 | 1021-1029 |
| Coal | 2.33 | |
| Shale | 11.67 | 1029-1043 |
| Sandstone | 14 | 1043-1057 |
| Shale | 1 | 1057-1058 |
| Coal | 1.16 | |
| Shale | 1.84 | 1058-1061 |
| Sandstone | 2 | 1061-1063 |
| Shale | 7 | 1063-1070 |
| Sandstone | 1 | 1070-1071 |
| Shale | 9 | 1071-1080 |
| Coal | 2 | 1080-1082 |
| Shale | 12 | 1082-1094 |
| Coal | 12.50 | |
| Bone | .50 | 1094-1107 |
| Coal | 11.16 | |
| Sandstone | 3 | |
| Bone coal | .25 | |
| Shale | 2.59 | 1107-1124 |
| Bone coal | .34 | |
| Castle Gate sandstone | 13.07 | 1124-1138 |

Figure 2.- Diamond drill-hole record



| Seam letter | Distance in tunnel | Drill hole elevation | Tunnel elevation | Thickness, drill-hole | Thickness, tunnel | Remark |
|---|---|---|---|---|---|---|
| A | 1480 | 5628 | 5646 | 10" | 14" | Uncertain |
| B | 1564 | 5564 | 5520 | 10" | 10" | |
| C | 1640 | 5536 | 5562 | 21" | 20" | |
| D | 1760 | 5489 | 5512 | 9" | 2'3" | |
| E | 1813 | 5446 | 5481 | 2'3" | 3'6" | |
| F | 1859 | 5429 | 5461 | 8" | 10" | |
| G | 1876 | 5412 | 5449 | 11" | 1'3" | |

Figure 3.- Tunnel development chart

The drill-hole records show the Castle Gate "A" coal bed to be 23 feet in thickness on this property and the "D" coal bed 16 feet 2 inches in thickness. Both are free from bands of impurity and are 184 feet apart vertically. An analysis of the "D" coal bed, which is the upper of the two coal beds and is taken at the point of intersection of the rock slope and the coal bed, under 1,800 feet of cover, is as follows:

| | Per cent |
|---|---|
| Fixed carbon | 53.67 |
| Volatile matter | 38.37 |
| Ash | 5.77 |
| Moisture | 2.19 |
| | 100.00 |
| Sulphur | .208 |
| B. t. u. | 15,332 |

The workable coal beds in the Book Cliffs district, with a few exceptions in the thinner beds, have the same physical characteristics, though the beds range in thickness from 4 to over 20 feet. The coal is usually free from impurities and is massive. So pronounced is the massive nature where the coal is fresh that seams or lines indicating stratification are scarcely discernible. It mines in irregular blocks, often of large size. The coal is not affected and does not slack to any appreciable extent on exposure to weathering agents. It is black and for the most part has a bright luster. It usually contains small irregular inclusions of a yellowish, brittle, resinlike bituminous substance scattered here and there, yielding an asphaltic odor on ignition. The coals are clearly within the bituminous grade and are remarkably uniform in composition. The sulphur content is low, the average being a little above one half of 1 per cent.

As the slopes were being driven seven other coal beds were encountered, ranging from 8 to 27 inches in thickness and at various distances, as shown in Figure 3.

## Openings

After the prospecting by diamond drilling had been completed to the satisfaction of the officials of the company, it was decided on account of the narrowness of the Canyon at this point to develop the property through a pair of rock slopes 1,973 feet long and 50 feet apart, dipping 30°, across the measures to intercept "D" coal bed. The slopes are now being extended 350 feet on the same dip to Castle Gate "A" coal bed.

Slopes on a 30° dip were used in preference to two deep vertical shafts to afford the following advantages:

1. Cost of two vertical shafts approximately 900 feet deep would involve a greater first cost than would be the case in driving two slopes 1,973 feet long on 30° dip.

2. The proximity of the Price River would involve constant danger of shafts acting as a sump for seepage water from the river, which would necessitate building an expensive pumping plant.

3. By making the slope openings at tipple height the danger from floods was eliminated.

4. Materials and supplies will be handled more economically through these slopes into the mine than would be possible if shafts had been chosen as the mine openings.

## Commencement and Completion of the Slopes

Preparations were made and work was commenced on April 28, 1928, as shown in Figure 3, to drive the main slope 14 by 8 feet in the clear and the air slope 10.5 by 9 feet in the clear, 50 feet apart, the main slope being 20 feet higher than the air course, both to be 1,973 feet long. After the main slope was driven in 50 feet on an 8 per cent dip and the air course 150 feet on an 8 per cent dip to form a landing the dip was increased to 30°, a difference of 7 feet in elevation being maintained throughout the entire distance to insure drainage into the air-course and to facilitate mucking from the main slope, while driving, 85 per cent of which was driven to the raise. (See fig. 3.)

Labor was paid on a day-wage basis, 8 hours constituting a day. The company furnished all materials and supplies. Direct supervision was under a man who had had considerable experience in this type of work. Since progress was not made as rapidly as the company anticipated the officials decided to make a change, and on April 29, 1929, supervision of the tunnels was placed in charge of the mine superintendent. Much better progress has been made since that time. The following table shows the progress made in feet each month during the entire period.

| Month | Main slope | Air course | Crosscuts |
|---|---|---|---|
| 1928 | | | |
| April | - | 100 | - |
| May | - | 186 | - |
| June | 57 | 96 | 50 |
| July | 24 | 136 | - |
| August | 22 | 113 | - |
| September | - | 145 | 28 |
| October | 9 | 185 | 32 |
| November | 85 | 121 | 40 |
| December | 27 | 148 | - |
| 1929 | | | |
| January | 60 | 132 | - |
| February | 182 | - | - |
| March | 49 | 116 | 60 |
| April | 70 | 100 | 11 |
| May | 163 | 88 | 22 |
| June | 130 | 64 | 78 |
| July | 170 | 90 | 12 |
| August | 181 | 120 | - |
| September | 252 | 33<br>(completed) | 50 |
| October | 249 | - | 50 |
| November | 243 (completed) | - | - |
| Total | 1973 | 1973 | 433 |

During the 20 months occupied in driving these slopes a total of 4379 feet of slope or crosscut was driven on an average of 218.95 feet per month, and 15,861.35 cubic yards of material was removed; or, if we assume 3,900 pounds as the average weight of a cubic yard of material, 30,929.6 tons of material was excavated.

## METHOD OF DRIVING

### Shifts and Number of Employees

The work was carried on in three 8 hour shifts each day, 7 days each week, the following classes of labor being employed in each shift.

1 shift boss
4 drillers
3 muckers
1 rope rider, who assisted mucking and attended pumps
1 hoistman outside
2 men disposing of the material.

### Drilling

Shot holes were drilled with air-driven jack hammers. Drifters were held in position by a horizontal bar. The drill steel was 1-inch hexagon hollow steel 11 feet long, dressed to a 2½-inch diamond point. In the main slope 32 shot holes and in the air course 30 shot holes constituted a round. The shot holes were drilled to a depth of 11 feet, on the slope angle as shown in Figure 4. Drilling was done while the mucking was being carried on and was a nearly continuous operation, four men and two drills being employed in this duty and an average round of shot holes being completed in 12 to 15 hours time.

### Blasting

All shots were fired electrically from the surface when all men were out of the mine, a special shot-firing line being constructed for this purpose.

The explosive used was 40 per cent gelatin. The cartridges were 8 inches long and 1 1/8 inches in diameter, 10 sticks being the maximum and 8 sticks the minimum used in each hole. Number 6 electric blasting caps were used, with delays numbering 1 to 9 at 3-second intervals. The shot holes were tamped to the collar with incombustible material, by means of a wooden tamping stick.

The following table shows the number of feet of advance made, pounds of explosive, and number of caps used, with the total cost for explosives per foot of advance during four average months.

| Month | Total feet advanced | Explosive used, pounds | Number of blasting caps used | Total cost of explosives | Cost of explosive per foot of advance |
|---|---|---|---|---|---|
| Jan., 1929 | 193 | 6100 | 1137 | $850.77 | $4.4081 |
| April, 1929 | 181 | 5300 | 1455 | 732.46 | 4.0467 |
| August, 1929 | 301 | 10750 | 1773 | 1485.65 | 4.9357 |
| Sept., 1929 | 335 | 9050 | 1232 | 1253.91 | 3.7429 |

## Mucking

In the air course the mucking was performed by hand loading, three men with the assistance of the rope rider forming the crew for this work. An average pull of 6 and one half feet was blasted with each round of shots, and was loaded or mucked out in about 9 hours, this including handling the water that accumulated at the face, so that mucking could be carried on comfortably.

In the main stope, 85 per cent of which was driven to the raise, the mucking was done with a scraper loader, the arrangement of the hoist, means of anchoring the head sheave, and loading and unloading point being shown in Figure 5.

A small portable double-drum scraper hoist was used, with a U-shaped scraper 3 feet wide in front and 4 feet long hauling about 15 cubic feet of material each trip. This would load the small car used to transfer the material through the crosscut, to be dumped in a larger car in the air course, which was used as the haulageway.

An average pull of 6½ feet was blasted with a round of shots and was mucked or loaded out by using the above mentioned scraper in about 4 hours.

## Haulage

A 75 hp. single-drum hoist, to which was attached a 3/4-inch steel cable and actuated by a 75 hp. 440-volt a.c. motor, was used for hoisting, one car to a trip. The mine car used was a bottom-dump car of wooden construction equipped with 18-inch wheels, run in roller bearings, carrying an average load of about 50 cubic feet of muck, a track gage of 42 inches being used.

While the hoisting was being done the workmen left the face for protection if a cable broke. On this pitch it is impossible to employ any practical derailing device. A careful watch was kept at all times of the condition of the cable and fastenings, with the result that no haulage accident of any kind has occurred.

## Disposal of Muck

When the loaded car was hoisted to the surface, the muck was dumped into a bin without detaching the car from the cable.

Two men were employed drawing the muck from this bin into a small steel car and depositing it in various depressions about the plant and along the banks of the river, until at this time it is difficult to observe where some 30,000 tons of refuse has been placed.

## Gas and Oil

Gas was first encountered in the air course about 850 feet from the surface and again at 1,600 feet accompanied by considerable quantities of oil, though not in large enough quantities to be collected for use. Oil was again found in small quantities oozing from the strata in the bed of sand rock immediately above "D" coal bed, making a noise like bees working in a hive. The gas was at no great pressure and bled off quickly. In the main slope which advanced to the raise small quantities of gas were encountered as each small coal bed was struck, but it was readily moved by the ventilation method employed. Small quantities of oil were also found in the same relative positions as in the air course.

## Water

A small quantity of water was encountered in the air course when it was down a distance of 350 feet from the surface and continued until a distance of 500 feet had been reached, when a small sump was made. The water, entering at the rate of about 18 gallons a minute, was pumped to the surface by two 4 by 6 inch pumps, belt-driven by 7½-hp. 220-volt a.c. motors placed in tandem, with a capacity of 60 gallons per minute against a 175-foot head.

From the 500-foot point until a distance of 1,240 feet had been reached the air course was dry and dusty, then a small quantity of water was made, after which the air course was dry until "D" coal bed had been reached - a distance of 1,973 feet. To take care of this small quantity of water a sump was made at the 1,300-foot point, and a small sinker air pump was used for pumping. It was belt-driven by a 5-hp. 220-volt a.c. motor with a capacity of about 400 gallons each 24 hours.

## Ventilation

The ventilation during the driving of these slopes entailed no unusual problems. Ventilation was supplied by two blower fans, driven by 1½-hp. 220-volt a.c. motors, and was conducted to the faces through corrugated pipe 12 inches in diameter.

## Timbering

No extensive means of roof support was required. In the main slope a few temporary 3-stick sets have been placed in position, but will be removed before coal-hauling operations commence. In the air course only three sets of timber have been required for roof support in the entire distance.

## Supervision

Inspection of the working face has been under the constant supervision of an experienced shift boss at all times while men were in the mine. He had no other duty but to inspect for gas and see that the working place was kept safe. The inspection for gas was made frequently during the shift by use of an approved flame safety lamp. The other employees used approved electric cap lamps.

## Accidents

No fatal or serious accident occurred, during the driving of these slopes and there were only 14 days time lost as the result of one minor injury.

## Cost data, expressed in percentage of total cost

| Classification | Per cent of total cost |
|---|---|
| Drilling and blasting | 31.18 |
| Mucking | 32.27 |
| Haulage | 16.40 |
| Disposal of material | 11.83 |
| Supervision | 8.32 |
| Totals | 100.00 |

Through these rock slopes will be developed one of the most valuable coal properties in Carbon County, Utah. An unusual mining problem presents itself, the mining of two coal beds 16 feet 2 inches and 23 feet in thickness, respectively, and 184 feet vertically apart. These lie at a depth of 1,800 feet, which depth will eventually increase several hundred feet as mining progressess.

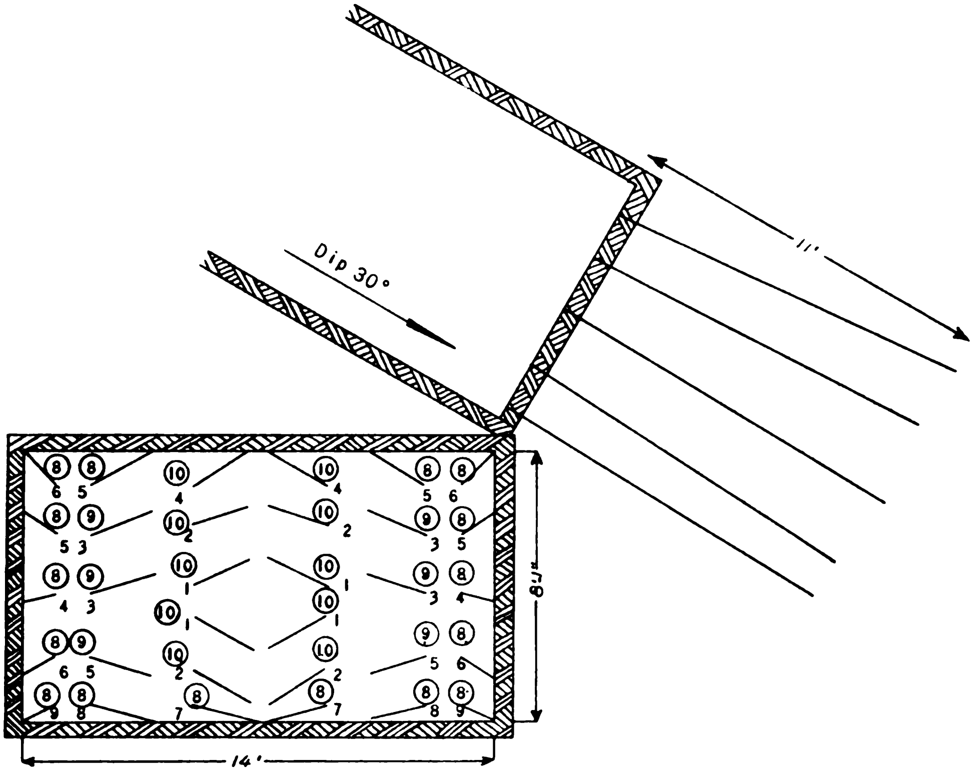


Figure 4.- Position of shot holes in slope round. In circles number of sticks used in each hole, the number at the mouth of the shot hole indicating the number of the delay cap used

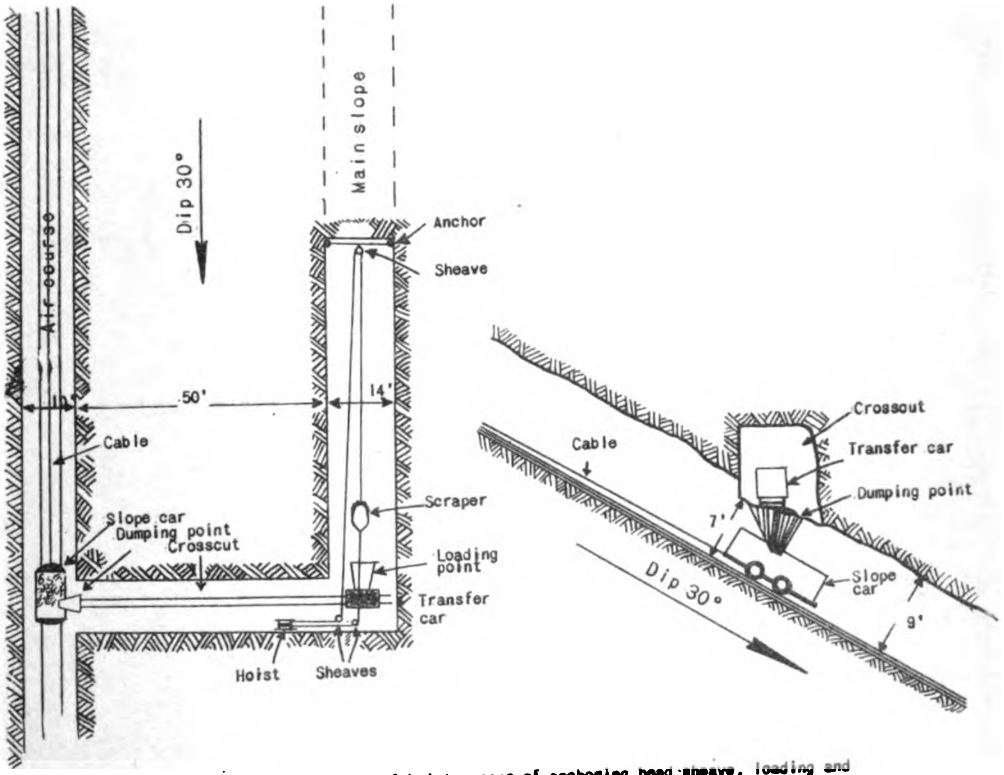


Figure 5.- Showing arrangement of hoist, means of anchoring head sheave, loading and unloading when driving main slope, 85 per cent of which was driven to raise